CENTRAL ASIAN JOURNAL OF WATER RESEARCH (2022) 8(1): 160-176

https://doi.org/10.29258/CAJWR/2022-R1.v8-1/160-176.eng

Central Asian Journal of Water Research

Dust Retaining Capacity of Deciduous and Coniferous Trees in Tashkent City, Uzbekistan

E.A. Zeybert [a], N.G. Akinshina [b], A.V. Mitusov [c]

[a] Plant Botany and Physiology Department, Biology School, Mirzo Ulugbek National University of Uzbekistan, 4 Universitetskaya Str., Tashkent, 100174, Uzbekistan
[b] Applied Ecology and Sustainable Development Department, Mirzo Ulugbek National University of Uzbekistan, 4 Universitetskaya Str., Tashkent, 100174, Uzbekistan;
[c] Kazakh-German University, 111 Pushkin Str., Almaty, 050010, Kazakhstan

This article is the translation of the article "Sravnenie pyleuderzhivajushhej sposobnosti listvennyh i hvojnyh porod goroda Tashkent, Uzbekistan [Сравнение пылеудерживающей способности лиственных и хвойных пород города Ташкент, Узбекистан]" published on March 13th, 2022.

ABSTRACT

This study aimed to investigate the dust-retaining capacity of tree crowns and analyze the possibility of utilizing this parameter to assess the air dust content in different parts of Tashkent City. The Dust Retention Index is expressed in the dust mass that a unit of green tree mass can hold. The plant material was collected at three sites in Tashkent with different environmental conditions (sunlight, temperature, dust sources) for the following species: catalpa (Catalpa bignonioides Walt.), london plane (Platanus acerifolia), Eldar pine (Pinus eldarica), and cedar red juniper (Juniperus virginiana). The research shows that compared to coniferous species the following deciduous species demonstrate higher dust retention values: plane (2.4, 1.2, and 13.3 mg/cm2, respectively), catalpa (8 and 3.6 mg/cm2, respectively), pine (0.185, 0.062, and 0.785 mg/cm2, respectively), and juniper (2.2 and 0.4 mg/cm2, respectively). The dust-retaining capacity was calculated based on the total dust emissions in Tashkent averaging 24.6±6.9 thou. tons per year (2009-2018). Plane is capable of retaining approx. 0.61%, and pine - approx. 0.16% of the mean annual (2009-2018) aerosol mass (per 100 thou. trees). The calculations allow concluding that in order to compensate (retain) the annual dust emissions in Tashkent, approximately 17-19 mln plane or 60-62 mln pine trees are necessary.

KEYWORDS

dust-retaining capacity, deciduous trees, coniferous trees, urban environment, dust, climate change.

CONTACT E.A. Zeybert zeybertk@gmail.com Mirzo Ulugbek National University of Uzbekistan, 4 Universitetskaya Str., Tashkent, 100174, Uzbekistan

Published by Kazakh German University, Almaty/Kazakhstan

1 Introduction

The recent decades have been showing an increasing climate change trend. The relatively stable temperature on Earth is maintained thanks to the greenhouse effect. Greenhouse gases (GHG) and dust particles let through solar rays and retain the planet's thermal radiation, thus contributing to the greenhouse effect [Vronsky, 1997]. The excess of the main greenhouse gas – SO_2 – and solid dust particles propel the greenhouse effect, resulting in the growing temperatures all across the planet [Nazarov et al., 2007]. The latter is the reason for multiple disasters [Semenov, 2015; Dyachkova, Berseneva, 2016].

Industry, urban development, and transport all boost the overall amount of GHG agents (greenhouse gases, dust and thermal pollution) in the atmosphere. In their study, Kartunova and Tsvetkov (2019) described the effects of dust on climate change. Dust sources can be divided into natural and anthropogenic. The first group includes deserts and steppes, the second – cities, construction sites, industrial clusters, and highways. The motorway dust comprises multiple pollutants as well [Kaygorodov et al., 2009]. Thus, cities make a significant contribution to the greenhouse effect.

Phytoindication methods are widely used to assess environmental pollution, in particular in urban environments [Neverova, 2009; Klevtsova et al., 2015]. Green spaces create favorable conditions, and the study of their morphological, physiological, environmental and other features allows characterizing both the state and growing condition of plants. For instance, Akhmerov and Shakhrinov (2018) used common pine in their air pollution assessment.

The studies in Almaty (Kazakhstan) demonstrate the dependence of dust retention on the type of plants and their physical location [Zhumadilova, 2014]. In the town of Orsk (Russia), they examined the dust-retaining ability based on littleleaf elm (*Ulmus parvifolia*) [Bagrin, 2019], in Yekaterinburg – based on dwarf apple (*Malus baccata*), mountain ash (*Sorbus aucuparia*), blood-red hawthorn (*Crataegus sanguinea*), and maple ash (*Acer negundo*) [Atkina, Ignatova, 2014].

Similar studies were conducted in Iran [Behjati, 2019; Javanmard et al., 2019] and various cities in China [Liu et al., 2013; Wu, 2019; Li et al., 2019; Sun et al., 2020], where air assessment is as relevant as in Uzbekistan.

Uzbekistan is located in the arid zone. The economic development and intensifying urban development, growing number of motor vehicles and industrial enterprises, as well as desertification negatively affect the state of atmosphere in cities. Tashkent as well as other cities and towns in the arid zone are characterized by the high dust particle content in the atmosphere [Yunusov, 2019]. Under these conditions, the ability of plants to sorb dust represents an important factor of improving urban ecology. It should be noted that different plant species possess different dust-retaining abilities and therefore, in order to create a stable and healthy habitat, it is necessary to investigate and evaluate these features.

The purpose of this study was to examine the dust-retaining capacity of plant crowns (catalpa – *Catalpa bignonioides Walt.*, london plane – *Platanus acerifolia*, Eldar pine – *Pinus eldarica*, and cedar red juniper – *Juniperus virginiana*) in the specific conditions of Tashkent City, Uzbekistan.

Research objectives:

1. Determine the dust-retaining capacity of tree crowns;
2. Identify the species most effectively sorbing dust on leafage and needles;
3. Analyze the possibility of using dust retaining capacity to assess dust air pollution;
4. Calculate the need for model plants to retain the main mass of pollutants emitted into urban air annually.

2 Study area

2.1. Tashkent City

The capital of Uzbekistan, Tashkent [www.geografiya.uz, 2018] is located in the Chirchik River Valley in the country's north-eastern part at the altitude of 440-480 m ASL. The city occupies 334.8 km^2, and has the population of 3.2 mln people (Fig. 1.).

Figure 1. Map of Tashkent (41°18' N, 69°16' E) [Google Maps, 2020].

2.2. Climate

Tashkent's climate is transitional with continental to subtropical temperatures. The mean year air temperature inside the city is +14.8°C. In January, it is +1.9°C, with the absolute minimum of -29.5°C recorded in December 1930. Spring in Tashkent lasts 1-1.5 months, and in April the mean daily air temperature exceeds +15°C. July is the hottest month, with the mean daily air temperature of +27.7°C. Tashkent's continental climate leads to extended heat waves. Thus, the daily air temperature from March to November can exceed +30°C, with the absolute maximum (+44.6°C) recorded in July 1997. The air cools faster in autumn, and by October it drops to +13.9°C. The total annual rainfall does not exceed 440 mm, with the monthly maximum (69 mm) observed in March, and the minimum (1 mm) in August. The predominant wind directions are eastern, western and north-eastern, explained by the peculiarities of the city's physical and geographical location and relief diversity [Information website of the Meteo-TV Channel, 2019].

2.3. Dust source

Tashkent is characterized by the high level of air-borne dust due to the city's geographic position. The dust content likewise depends on the anthropogenic dust sources (construction sites, highways, industrial and energy facilities, construction and solid municipal waste landfills, etc.). According to Uzhydromet (Uzbekistan's hydrometeorological service), over the past 10 years, background dust contamination in Tashkent has been exceeding the daily mean permissible concentration (MPC) by 1.3-2.7 times [90% of atmospheric emissions in Tashkent are from vehicles, 2019]. The mean mass of pollutants released into the atmosphere from 2009 to 2018 amounted to 24.6±6.9 thou. tons [State Committee on Statistics, 2019]. In 2016, the length of city roads exceeded 630 km [Isayev, 2016]. The city has 18 bus districts, each comprising 150-260 buses [Tashkent Bus Fleets, 2019], and about 60 bus lines [Tashkent Bus Routes, 2019]. At present, the city is actively building two metro lines - Yunusabad and Sergelyskaya, as well as business centers - Tashkent City, Olmazor City, Yunusobod Business City, Mirzo Ulugbek Business City, etc. [Novikov, 2019].

2.4. Sampling sites

As per the research objectives, three sampling sites were identified within the city, each distinguished by specific natural and anthropogenic conditions.

The first site - the conditional *Construction Site* - represented a model construction site on the border between Quarters 11 and 13 of Yunusabad District of Tashkent along Ahmad Donish Street (Fig. 2.), with ongoing metro station building efforts. In addition, roads run from both sides of the construction site, stimulating air dust. The sampling plants were located in the immediate vicinity of the dust source.

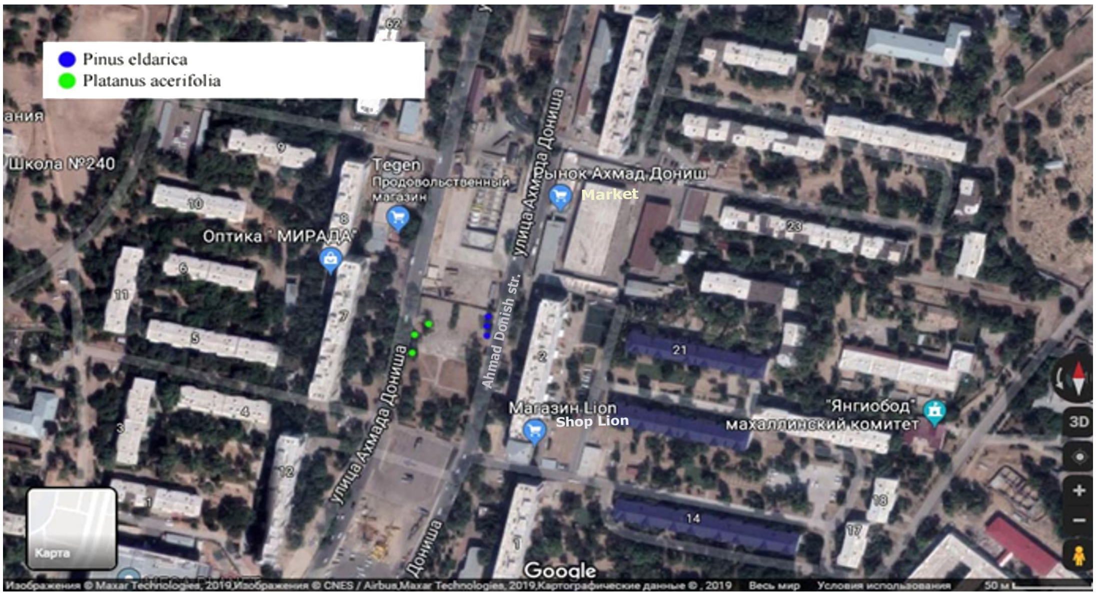

Figure 2. Construction Sampling Site [Google Maps, 2020]. Note: the observed trees marked by points (blue – Eldar pine, green – london plane).

The second sampling site – *Road* – was the green zone near the intersection of Malaya Koltsevaya (Ring) Road and Ahmad Donish Street in Almazar District of Tashkent (Fig. 3.) with rather dense traffic. The plant leaves at that site had dust bloom, clearly visible even on fir needles. All sampling trees grew on the road side.

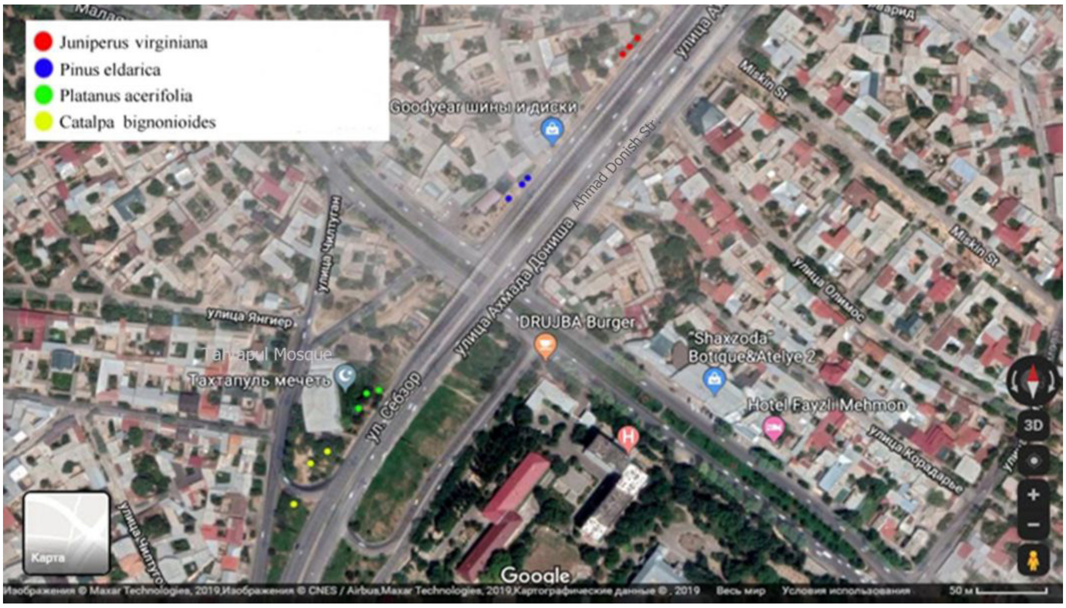

Figure 3. Road Sampling Site [Google Maps, 2020). Note: the observed trees marked by points (red – cedar red juniper, blue – Eldar pine, green – london plane, and yellow – catalpa).

The third sampling site - *Educational Establishment* (Fig. 4.) - represented the premises around the Faculty of Physics of Mirzo Ulugbek National University of Uzbekistan located on Studencheskaya Street in Almazar District. The site directly bordered neither on roads nor on construction sites, i.e. the dust sources were present, yet were located at a distance from the sampling plants.

Figure 4. Educational Establishment Sampling Site [Google Maps, 2020]. Note: the observed trees marked by points (red - cedar red juniper, blue - Eldar pine, green - london plane, and yellow - catalpa).

2.5. Research subjects

Four species of woody plants - Eldar pine, cedar red juniper, london plane, and catalpa (common) - were selected for this dust retention study (Table 1.).

Table I. Research subjects.

Species / Parameter	**Eldar pine (*Pinus eldarica*)**	**Cedar red juniper (*Juniperus virginiana*)**	**London plane (*Platanus acerifolia*)**	**Common catalpa (*Catalpa bignonioides Walt.*)**
System affiliation	*Pinaceae*	*Cupressaceae*	*Platanaceae*	*Bignoniaceae*
Life form	tree	tree	tree	tree
Assimilation organs	needle fir	lepidote fir	5-lobar leaves	heart-shaped leaves
a) surface quality	smooth, resinous	smooth, resinous	smooth (top), downy (bottom)	downy, sticky
b) cuticle	+	++	+	+++
c) lifespan	2-3 years	1.5-2 years	spring-autumn	spring-autumn
d) size	10 cm long	0.1-0.2 mm lepidote fir	15-17 cm long, 18-20 cm wide	30 cm long, 17 cm wide

Note: Description of cedar red juniper corresponds to the [Trees and Shrubs of the USSR, 1954, p. 252]; other species [Slavkina, Podolskaya, 1987, pp. 59, 64, 91].

The choice of these species as research subjects was due to their frequent use in urban landscaping and morphological diversity of their vegetative organs. This fact allowed analyzing the influence of various plant features – such as lamina shape and integrity, texture, presence or absence of wax bloom, etc. – on dust retention [Yerokhin et al., 1987]. For example, juniper is well suited for creating alleys and hedges; combined with pine, juniper is also recommended for landscaping the premises of medical and children's establishments. Deciduous broad-crown trees are better suited for inner-block plantations [Pechenitsyn et al., 2005].

3. Research methods

3.1. Sampling

At the time of sampling, the last precipitation was in mid-June, and the collection of plant material was carried out during September 15-25, 2019, thus the samples contained the dust accumulated in the course of 3 months. This period is the most appropriate time for dust accumulation by green plant mass [Behjati, 2019]. At each sampling site, leaves of approximately the same age and size were collected in the amount of 15-20 pieces from three trees of the selected species towards a dust source at 1.5-2 m above the ground and 10-30 cm deep into the crown. The coniferous samples were collected in the form of twigs (3-5) with needle fir (Fig. 5.).

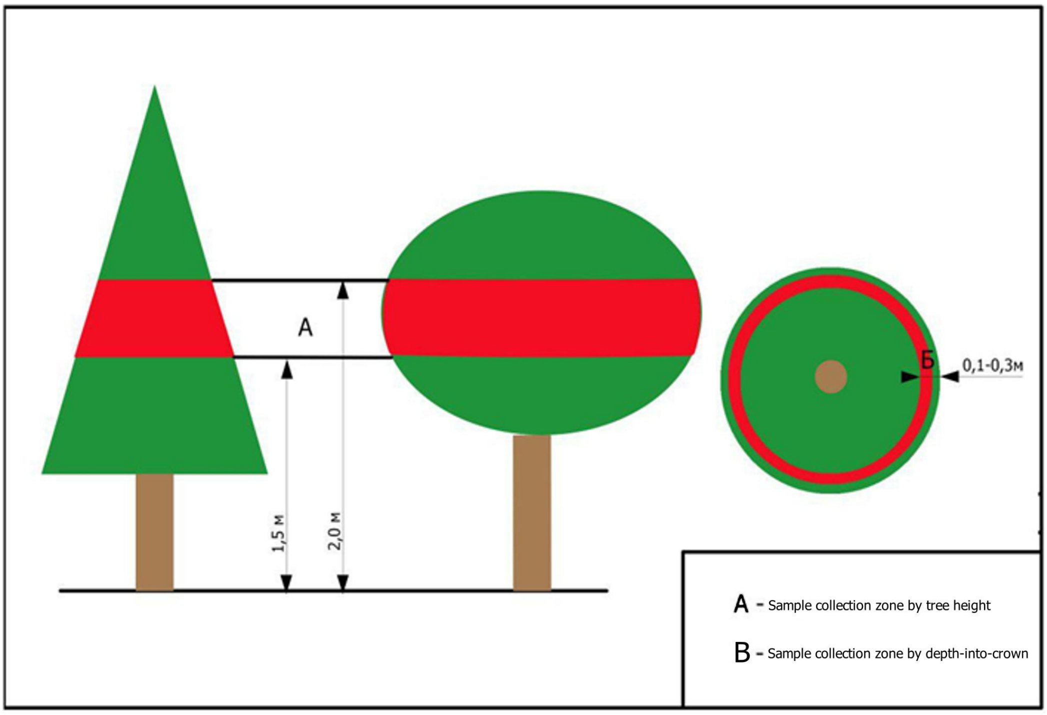

Figure 5. Sampling design.

3.2. Rinse sampling

Dust retention was determined by rinsing dust from the green mass surface. The rinsing was done using distilled water into chemical glasses. The rinsed output underwent filtering through filter paper pre-dried to constant weight, and then weighing. After filtering, the filter paper with dust particles underwent drying in the drying cabinet (ShS-80-01 SPU, Smolensk SKTB SPU, Russia) at 105°C to constant mass. The difference in filter paper mass prior and after filtration allowed identifying the mass of dust held by leaves or needles. Dust retention was expressed in mg of dust per cm^2 of leaf/needle area [Wu, 2019].

3.3. Leaf and fir-needle area calculation

Juniper lamina and needle area can be determined based on the weight-change method using millimeter paper. Considering that the known area of millimeter paper has constant weight, five 10 cm^2 paper pieces were weighed, and the mean weight was taken as reference. Further, the leaf contours of sampling trees were transferred to the millimeter paper, cut and weighed. Lamina area calculations were done as per Formula (1) below.

$$\boldsymbol{S_x} = \boldsymbol{S} * \frac{m_x}{m}, \quad (1)$$

, with $\boldsymbol{S_x}$ as the sought lamina area, $\boldsymbol{S}$ as the reference area (10 cm^2), $\boldsymbol{m_x}$ as the mass of a millimeter paper sheet of the sought area, and $\boldsymbol{m}$ as the reference mass [Irbe, Marakayev, 2004].

This method was not suitable for pine, and thus the method for calculating fir needle area proposed by Sungurova and Khudyakov (2015) was applied. The length, width and thickness of 100 sampled fir needles were measured by means of sliding caliper with the accuracy of ±0.1 mm; and the area calculations were done as per Formula (2) below.

$$\boldsymbol{S} = 5.14\boldsymbol{L}\left(\frac{a+\frac{b}{2}}{2}\right), \quad (2)$$

, where $\boldsymbol{S}$ is the area of one needle (mm^2), $\boldsymbol{L}$ is needle length (mm), $\boldsymbol{a}$ is needle thickness (mm), and $\boldsymbol{b}$ is needle width (mm).

3.4. Model calculations

3.4.1. Model tree

A model tree is an average tree model under study, the crown area of which was used for calculations. The model was created based on the obtained mean area values of lamina or fir needle multiplied by their total number (Formula (3)). The mean lamina or needle area was calculated based on the area values of all plant samples used to determine the dust-retaining capacity. The mean quantity of leaves or needles was calculated based on their average number on 30-50 trees obtained by direct counting on the sampling trees and nearby trees of the same species.

$$S_{total} = S * n, \qquad (3)$$

, with S_{total} as the total crown area (cm^2), S as the average area of one leaf or needle (cm^2), and n as the number of leaves or needles on one tree.

3.4.2. Calculation of dust-retaining capacity per model tree

The average model was used for calculating the total plant crown area. The amount of dust that one tree can retain on average was calculated as per Formula (4) below.

$$M = A * S, \qquad (4)$$

, where M is the mass of dust on one tree (mg), A is the dust-retaining capacity (mg/mm^2), and S is crown area (mm^2).

The obtained values allow calculating the need for (quantity of) trees of a certain species to compensate for the total urban dust emissions as per Formula (5).

$$K = \frac{M_{total}}{M}, \qquad (5)$$

, with K as the number of trees required to compensate for the total dust emissions, M_{total} as the mass of total dust emissions in Tashkent (kg), and M as the mass of dust retained by one tree (kg).

Knowing the mass of dust retained by one model tree, the percentage (share) of urban air pollution compensation by 100,000 trees can be calculate as per Formula (6).

$$K_{\%} = \frac{M}{M_{total}} * 100\%, \qquad (6)$$

, where $K_{\%}$ is the percentage of air pollution compensation per 100,000 trees (%), M is the mass of dust retained by 100,000 trees (kg), M_{total} is the mass of total urban dust emissions per year (kg).

3.5. Statistical data analyses

To obtain statistically significant outputs, the arithmetic mean values of the replications were calculated. The statistically unreliable and/or clearly false outputs admitted during sample collection and analysis were dismissed. The standard deviation was calculated for each mean value. The differences in mean values were considered valid if the distance between the curve points exceeded one standard deviation. All calculations were performed in MS Office Excel 2007.

4. Research results

4.1. Dust-retaining capacity

The study results point to the highest air dust content at the Construction Sampling Site, as evidenced by the higher amount of dust deposited on the green mass of plane and pine (Fig. 6.). The dust-retaining value for pine (0.785 mg/cm^2) at that site exceeded the one at the Educational Establishment Sampling Site 12.6 times, and 4.24 times – that at the Road Sampling Site. For plane, the dust-retaining value at the Construction Sampling Site (13.3 mg/cm^2) was 11.08 times over the value at the Educational Establishment Site, and 5.54 times more than that at the Road Sampling Site.

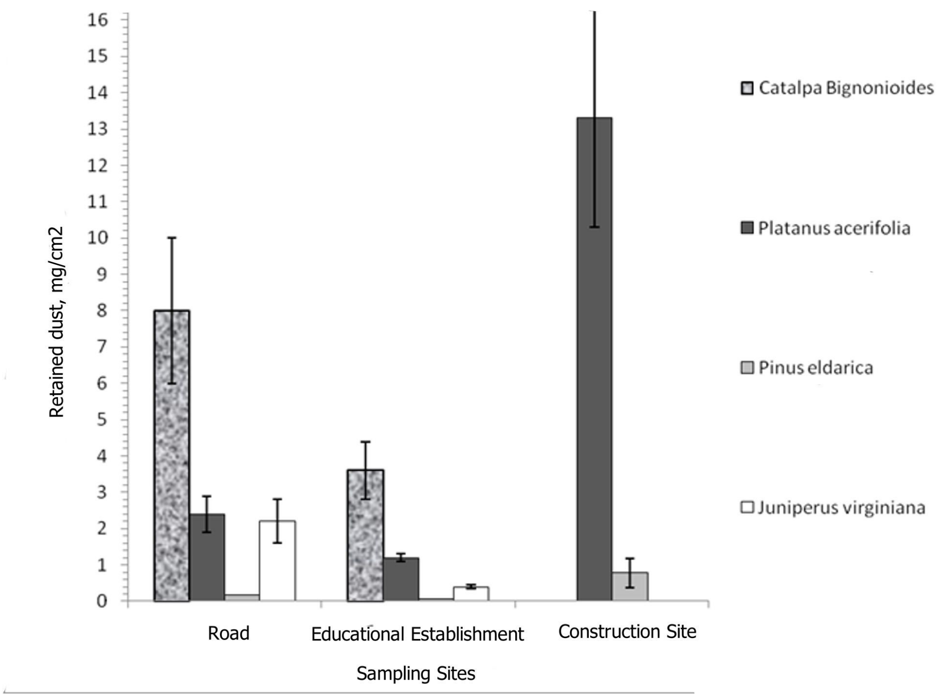

Figure 6. Dust-retaining capacity of tree species (mg/cm^2) at sampling sites.

Note: at the Construction Sampling Site, sampling was done for two species (london plane and Eldar pine). The bars denote the range of mean standard deviations.

The mean dust-retaining values at the Road Sampling Site for catalpa (8 mg/cm^2) were 2.2 times higher than these at the Educational Establishment Sampling Site; for plane, 2 times higher (2.4 mg/cm^2); for pine, 3 times higher (0.185 mg/cm^2);

for juniper, 5.5 times higher (2.2 mg/cm^2). The lowest dust-retaining capacity was observed at the Educational Establishment Site with the following values: catalpa – 3.6 mg/cm^2, london plane – 1.2 mg/cm^2, pine – 0.062 mg/cm^2, and juniper – 0.4 mg/cm^2.

The species dust-retaining differences deserve a separate mention. Thus, comparing the values for the Road and Educational Establishment Sampling Sites, catalpa demonstrated the maximum performance – 8 and 3.6 mg/cm^2, respectively. The minimum values were observed for Eldar pine – 0.185 and 0.062 mg/cm^2, respectively. London plane and cedar red juniper took the second and third positions as to their dust-retaining performance – the former showed 1.2 mg/cm^2 at the Educational Establishment Sampling Site and 2.4 mg/cm^2 at the Road Sampling Site; the latter showed 0.4 and 2.2 mg/cm^2 for the same sites, respectively.

4.2. Model tree calculations

Rough models for plane and pine trees aimed to calculate the mass of dust that one plant could retain on itself (see Formula (4)) and the corresponding percentage of air pollution compensation, i.e. weight share of the total dust emissions in Tashkent that 100,000 trees of the aforementioned species were capable of retaining. Thus, the model plane (generative age, green mass area 25.5±3 m^2) can retain up to 1.5 kg of dust, i.e. 100,000 london plane trees can hold approx. 0.61% of the total weight of mean annual pollutant emissions in Tashkent City. Along the same vein, one pine (over 10-12 years old, average height 10-11 m, green mass area 110±5 m^2) can hold up to 0.4 kg of dust, i.e. 100,000 pine trees are capable of retaining 0.16% of the total emission weight (see Formula (6)). About 17-19 mln london plane or 60-62 mln pine trees (see Formula (5)) are required to completely retain the pollutants emitted in 2019.

5. Discussion

5.1. Tashkent City

The study allowed detecting the two main reasons underpinning the different dust-retaining capacity of the same tree species, specifically growing conditions and species features.

Overall, the air condition is influenced by the dust sources in a certain area. Thus, near the construction site, the amount of air-borne dust was the highest due to the use of various building materials and earthworks. The air over the area along the road still contained a significant amount of dust, yet less than near the construction site, with cars and the actual roadway as the main dust sources. The lowest amount of dust was observed near the educational establishment, with the air much cleaner due to abundant vegetation and remoteness from roads (Fig. 6.).

A species dust retention features are associated with the morphological structure of its leaves or needles. The presence of a cuticle and lamina downiness contribute to the retention of dust particles on it, as opposed to smooth surface, from which dust is easily blown away. Dust retention is also dependent on lamina size and degree of irregularity (roughness) – large whole leaves hold dust more effectively. Thus, large and solid catalpa leaves with expressed cuticle and downiness demonstrate the highest dust-retention capacity. The leaves of london plane – large and lobed – have less pronounced cuticles and downiness compared to catalpa but still contribute to their good dust retention. Dust retention of needle fir is facilitated by the resin cuticle covering the needles. Comparing the species specific dust-retaining values for the Educational Establishment and Road Sampling Sites, the downward sequence as to their performance appeared as follows: *Catalpa bignonioides* > *Platanus acerifolia* > *Juniperus virginiana* > *Pinus eldarica*.

Coniferous trees are inferior to deciduous in dust retention, as evidenced by the lower values of their dust-retaining capacity under this study. However, it should be borne in mind that – unlike deciduous crowns – coniferous crowns stay on the trees all year round and possess pronounced phytoncidal properties [Kochergin, 2009].

5.2. Comparison with other cities

While analyzing the results of this study, it is necessary to take account of the significant influence of geographical location, climate and terrain differences, as well as the different species composition of compared territories on the investigated parameter. The areas under this study are surrounded by deserts and steppes, and are characterized by high solid particle content in the air. The mountain relief acts as a "wall" protecting the areas against wind flows carrying dust from the neighboring territories. Likewise, climate, precipitation and humidity affect the rate of dust settlement. The listed conditions predetermine the species composition in the study area. Plant species most adapted to local growing conditions are capable of fully manifesting their ecological potential.

Similar studies conducted in the cities of Guangzhou, Shanghai, Yangzhou, Kunming (China) indicate the dependence of dust-retaining capacity on leaf morphological characteristics and ecological conditions of plant growth [Liu et al., 2013; Wu, 2019; Li et al., 2019; Sun et al., 2020]. London plane – used in Tashkent – was one of the study subjects in the city of Kunming, with the dust-retaining capacity samples collected at similar sites (industrial zone, highway, and educational establishment premises). Comparing the maximum dust-retaining capacity values for london plane in the cities of Kunming (3.43 g/m^2) and Tashkent (56.3 g/m^2), it requires noting that in the conditions of the latter, the amount of dust settling on one square meter of lamina is 16.4 times higher [Li et al., 2019] – clearly illustrating the difference in the overall environmental conditions of these urban communities.

Kazakhstan and Uzbekistan are located in the semi-arid zone. Interesting results were obtained for Almaty [Zhumadilova, 2014] in the research that examined balsam poplar (*Populus balsamifera*), maple ash (*Acer negundo*), wheeping birch (*Betula verrucosa*), small-leaved linden (*Tilia cordata*), dwarf apple (*Malus baccata*), Siberian mountain ash (*Sorbus sibirica*), common pine (*Pinus sylvestris*), common lilac (*Syringa vulgaris*), cotoneaster (*Cotoneaster melanocarpus*), and Siberian pea shrub (*Caragana arborescens*). The author presented dust retention in dust mass (mg) per 1 plant leaf. The range of the parameter values varied depending on the sampling site, and was similar to the results obtained in Tashkent, i.e. whereas green areas demonstrated the least amount of dust settling on tree crowns, the highest values were observed in the city center. Converting the dust retention values per leaf for tree species in Tashkent City showed that they closely ranged within approx. 90-120 mg/leaf.

6. Conclusion

The results of this study confirm the great importance of plant cover in maintaining favorable living conditions, in particular the quality of urban air. Phytoindication methods are widely used to provide recommendations for landscaping urban zones of different significance, as well as allow to correctly determine the species composition for these zones with the account of their environmental features. On the one hand, dust retention is an important property of plants; on the other hand, it is a parameter reflecting the overall state of the environment in the actual locations of their growth, which – as a phytoindication method – can be used for objective environmental assessment.

Based on the study results, it is possible to draw the following conclusions.

The dust content of urban air is different, reflected by the different dust mass settling on plants in different city districts (areas). Overall, the air condition is influenced by an area’s dominant purpose (residential area, motorway, industrial zone, green area, construction site);

The comparison of the dust retention capacity of the plants examined within the framework of this study confirmed the dependence of dust holding on the morphological features of different species. The cuticle and lamina downiness contribute to better retention of dust particles and make it difficult for wind to blow them off. Characterized by the small needle area and smooth surface, coniferous trees are inferior to deciduous ones in dust retention. Yet, being evergreen, the former are capable of holding dust regardless of season, reflecting the needs of dry climate regions;

Of the investigated plants, catalpa (*Catalpa bignonioides Walt.*), often found in the green zones of Tashkent, retained dust most efficiently;

The percentage of air pollution compensation allows objectively determining the quantity of seedlings necessary depending on the tree species and air dust content.

7. Recommendations

Based on this study results, the authors recommend using the tree species examined herein for landscaping of the cities of the Republic of Uzbekistan and neighboring countries.

When creating green zones, it is recommended to establish mixed plantations. Thus, juniper and pine, the crown of which is distributed along the entire trunk length, should be planted closer to dust source; catalpa and plane, whose crown strives upward, should be planted behind them. Following this planting pattern allows creating a uniform and solid green “fence”.

Knowing how much dust is emitted into air at a certain time, as well as how much dust the crown of a given tree species can retain allows calculating the quantity of such trees required. The percentage of air pollution compensation presented in this article can be used to calculate the share of each tree species in a group plantation, i.e. how many coniferous and/or deciduous plants are necessary to retain the predicted amount of dust.

Based on the results obtained, it is necessary to continue the research and expand the species composition used for landscaping, as well as determine the fractional and chemical composition of deposited aerosols.

Acknowledgement

The article was executed with the support of Regional Environmental Centre for Central Asia (CAREC) within the framework of the Student Research Competition on Sustainable Management of Natural Resources in Central Asia (2019-2020). Ms. E. Zeybert received the scholarship under the competition, and Dr. A. Mitusov served as her research supervisor. The authors express gratitude to the competition sponsors and organizers both for financial support and international scientific networking opportunities. The research was carried out as part of the efforts at the Department of Applied Ecology and Sustainable Development of Mirzo Ulugbek National University of Uzbekistan in Tashkent under Grant BV-M-F-5-001 (2017-2020) *Adaptive plant strategies for stress factors in urban conditions, role of photosynthesis and respiration in plant resilience*. The authors express particular gratitude to colleagues for their moral support and valuable advice during the research. In conclusion, the authors highly appraise the Academic Writing YouTube Channel (Academic Writing, 2020) containing concise and clear description of the modern research article architecture; the information has proved useful in both structuring and formatting this article.

References

90% of atmospheric emissions in Tashkent come from vehicles [*90 % vybrosov v atmosferu v Tashkente prihoditsja na avtotransport*] (2019). Newspaper.uz Website (accessed: September 26, 2019), available at: https://www.gazeta.uz/ru/2019/08/ 12/air-pollution/ [in Russian]

Academic Writing YouTube Channel (accessed: February 17, 2020). Available at: https://www.youtube.com/channel/UC4gmv525RjgB2RNqX3QBIQg

Akhmerova, D.N., Shakhrinova, V.N. (2018). Bio-indication of atmospheric air pollution based on the condition of common pine needles in the town of Birsk [*Bioindikacija zagrjaznenija atmosfernogo vozduha po sostojaniju hvoi sosny obyknovennoj na territorii goroda Birsk*]. Science and Education Achievements. Biological sciences [*Dostizhenija nauki i obrazovanija. Biologicheskie nauki*], 8 (30), I, 7-9 [in Russian]

Atkina, L.I., Ignatova, M.V. (2014). Features of dust-retaining capacity of the leaves of Malus baccata L., Sorbus aucuparia L., Acer negundo L., Crataegus sanguine L. in urban plantations of Yekaterinburg [*Osobennosti pyleuderzhivajushhej sposobnosti list'ev Malus baccata L., Sor-bus aucuparia L., Acer negundo L., Crataegus sanguine L. v gorodskih posadkah Ekaterinburga*]. Russia's Forests and Forestry [*Lesa Rossii i hozjajstvo v nih*], 4 (51), 79-82 [in Russian]

Bagrin, S. (2019). Dust-retaining ability of elm leaves in the town of Orsk [*Pyleuderzhivajushhaja sposobnost' list'ev Vjaza melkolistnogo v gorode Orske*]. Pandia.ru. Publishing Platform (accessed: September 15, 2019). Available at: https://pandia.ru/text/80/521/69918.php [in Russian]

Behjati, S.E. (2019). A relative analysis of carbon and dust uptake by important tree species in Tehran, Iran. *International Journal of Environmental and Engineering,* 13(4), 222-225 (https://doi.org/10.5281/zenodo.2643941)

Dyachkova, T.V., Berseneva, I.A. (2016). Greenhouse effect: reasons, impacts, and forecasts [*Parnikovyj jeffekt: prichiny, posledstvija, prognozy*]. Global environmental challenges: materials of the All-Russian Scientific and Practical Conference with international participation [*Global'nye problemy jekologii: materialy Vserossijskoj nauchno-prakticheskoj konferencii s mezhdunarodnym uchastiem*]. Orekhovo-Zuyevo: Editorial and Publishing Department of the State Technical University, 34-43 [in Russian]

Geografiya.uz website (2018). Geographical location of Uzbekistan. Boundaries and area [*Geograficheskoe polozhenie Uzbekistana. Granicy i ploshhad'*] (accessed: October 7, 2019). Available at: http://geografiya.uz/fizicheskaya-geografiya-uzbekistana/10002-geograficheskoe-polozhenie-uzbekistana-granicy-i-ploschad.html [in Russian]

Google Maps website (2020). Accessed: October 7, 2019

Irbe, I.K., Marakayev, O. A. (2004). Plant physiology: methodological recommendations for performing laboratory work for students [*Fiziologija rastenij: metodicheskie ukazanija k vypolneniju laboratornyh rabot dlja studentov*]. Ministry of Education of the Russian Federation, Kurgan: Kurgan State University, 23-24 [in Russian]

Isaev, T. (2016). The length of Tashkent motorways will increase by 40% [*Protjazhennost' dorog Tashkenta uvelichitsja na 40%]*. Podrobno.uz News Agency (accessed: September 29, 2019). Available at: https://podrobno.uz/cat/obchestvo/protyazhennost-dorog-tashkenta-uvelichitsya-na-40/ [in Russian]

Javanmard, Z., Kouchaksaraei, M.T., Bahrami, H., Hosseini, S.M., Sanavi, S., Struve, D. (2019). Dust collection potential and air pollution tolerance indices in some young plant species in arid region of Iran. *iForest – Biogeosciences and Forestry*, 12(6), 558-564 (doi: https://doi.org/10.3832/ifor3063-012)

Kartunova, L.S., Tsvetkov, G.S. (2019). The Earth's global climate change: warming or cooling? [Global'nye izmenenija klimata Zemli: poteplenie ili poholodanie?]. *Science, education and culture [Nauka, obrazovanie i kul'tura]*, 2 (36), 53-63 [in Russian]

Kaygorodov, R.V., Tiunova, M.I., Druzhinina, A.V. (2009). Pollutants in urban roadway dust and roadside vegetation strips [*Zagrjaznjajushhie veshhestva v pyli proezzhih chastej dorog i v drevesnoj rasti-tel'nosti pridorozhnyh polos gorodskoj zony*]. Perm University Bulletin, 10 (36), 141-146 [in Russian]

Klevtsova, M.A., Mikheyev, A.A., Yakunin, A.I. (2015). Environmental assessment of air pollution by bio-indicator methods [*Jekologicheskaja ocenka zagrjaznenija vozdushnoj sredy bioindikatornymi metodami*]. Volga Region Scientific Bulletin [*Privolzhskij nauchnyj vestnik*], 3-2 (43), 82-85 [in Russian]

Kochergina, M.V. (2009). Phytoncidal properties of common pine (Pinus sylvestris L.) in the green zone of the town of Voronezh [*Fitoncidnye svojstva sosny obyknovennoj (Pinus sylvestris L.) v uslovijah zelenoj zony g. Voronezh*]. Landscape architecture and garden and park development: Modern issues [*Landshaftnaja arhitektura i sadovo-parkovoe stroitel'stvo: sovremennye problemy*]. Materials of the international scientific and practical conference (September 3-4), Voronezh, 121-130 [in Russian]

Li, Y., Wang, Sh., Chen, Q. (2019). Potential of thirteen urban greening plants to capture particulate matter on leaf surfaces across tree level of ambient atmospheric pollution. *International Journal of Environmental Research and Public Health*, 16(3), 402 (doi: 10.3390/ijerph16030402)

Liu, L., Guan, D., Peart, M.R., Wang, G., Zhang, H., Li, Zh. (2013). The dust retention capacities of urban vegetation – a case study of Guangzhou, South China. *Environmental Science and Pollution Research,* 20, 6601-6610 (doi: 10.1007/s11356-013-1648-3)

Meteo-TV Channel Information Website (2019). Climate: Tashkent (accessed: September 21, 2019. Available at: http://www.meteo-tv.ru/uzbekistan/tashkent/ weather/climate/ [in Russian]

Nazarov, B.I., Maslov, V.A., Abdullayev, S.F. (2007). On the impacts of dust aerosols on air temperature [*O vlijanii pylevogo ajerozolja na temperaturu vozduha*]. Reports of the Academy of Sciences of the Republic of Tajikistan [*Doklady Akademii nauk Respubliki Tadzhikistan*], vol. 50, No. 4, 340-344 [in Russian]

Neverova, O.A. (2009). Phyto-indication in environmental pollution assessment [*Primenenie fitoindikacii v ocenke zagrjaznenija okruzhajushhej sredy*]. Biosphere, vol. 1, No. 1, 82-92 [in Russian]

Novikov, V. (2019). In 2019 Tashkent became the center of large-scale construction [*Tashkent v 2019 godu stal centrom masshtabnogo stroitel'stva*]. News of Uzbekistan (accessed: September 29, 2019). Available at: https://nuz.uz/ekonomika-i-finansy/40194-tashkent-v-2019-godu-stal-centrom-masshtabnogo-stroitelstva.html [in Russian]

Pechenitsyn, V.P., Azamov, A.A., Shtonda, N.I., Yesipova, T.V. (2005). Landscaping Culture [*Kul'tura ozelenenija*]. Tashkent: Shark Publishing House, 28-30, 36 [in Russian]

Semenov, S.M. (2015). Greenhouse effect: Discovery, concept evolution and role in shaping global climate and its anthropogenic changes [*Parnikovyj jeffekt: otkrytie, razvitie koncepcii, rol' v formirovanii global'nogo klimata i ego antropogennyh izmenenij*]. *Fundamental and applied climatology [Fundamental'naja i prikladnaja klimatologija]*, 2, 103-126 [in Russian]

Slavkina, T.I., Podolskaya, O.I. (1987). Decorative Gardening. Community Landscaping [*Dekorativnoe sadovodstvo. Ozelenenie naselennyh mest*]. Tashkent: *Mekhnat* [in Russian]

Sun, Y., Lin, W., Li, Y. & Xu, D. (2020). Dust deposition on vegetation leaves in Shanghai, China. *International Journal of Environmental Health Research*. 31(3), 1-14 (doi: 10.1080/09603123.2020.1714559)

Sungurova, N.R., Khudyakov, V.V. (2015). Pine assimilation apparatus [*Assimiljacionnyj apparat v kul'turah sosny*]. *Scientific Notes of Petrozavodsk State University [Uchenye zapiski Petrozavodskogo gosudarstvennogo universiteta]*, 8 (153), 68-74 [in Russian]

Tashkent bus parks [*Avtobusnye parki Tashkenta*] (2019). Tash-Trans.uz Information Portal (accessed: October 12, 2019). Available at: https://tashtrans.uz/ avtobusnye-marshruty-tashkenta/ [in Russian]

Tashkent bus routes [*Avtobusnye marshruty Tashkenta*] (2019). Tash-Trans.uz Information Portal (accessed: October 12, 2019). Available at: https://tashtrans.uz/ avtobusnye-marshruty-tashkenta/ [in Russian]

Trees and shrubs of the USSR. Wild, cultivated and potential for introduction [*Derev'ja i kustarniki SSSR. Dikorastushhie, kul'tiviruemye i perspektiv-nye dlja introdukcii*] (1954). Ed. by Sokolov, S.Ya.], Moscow-Leningrad: Publishing House of the USSR Academy of Sciences, vol. III, 252 [in Russian]

Vronsky, V.A. (1997). Ecology Reference Dictionary [*Jekologija: slovar'-spravochnik*]. Rostov-on-Don: *Feniks*, 367-368 [in Russian]

Website of the State Committee of the Republic of Uzbekistan on Statistics (2019). Ecology [*Jekologija*] (accessed: October 7, 2019). Available at: https://stat.uz/ru/otkrytye-dannye [in Russian]

Wu, Y. (2019). Assessment model of dust-retention effect of green planting in landscape under the concept of eco-environmental protection. *Ekoloji*, 28(108), 2153-2157

Yerokhina, V.I., Zherebtsova, G.P., Wolftrub, T.I., Pokalov, O.P., Shurova, G.V. (1987). Community Landscaping Handbook [*Ozelenenie naselennyh mest: spravochnik*]. Moscow: *Stroyizdat*, 10-15 [in Russian]

Yunusova, H.E. (2019). History of atmospheric air pollution in Uzbekistan (1969-1980) [*Istorija zagrjaznenija atmosfernogo vozduha v Uzbekistane (1969-1980)*]. *Science and Education Bulletin [Vestnik nauki i obrazovanija]*, 15 (69), 42-46 [in Russian]

Zhumadilova, A.J. (2014). Dust-retaining ability of tree and shrub plants [*Pyleuderzhivajushhaja sposobnost' drevesnyh i kustarnikovyh rastenij*]. Science News of Kazakhstan [*Novosti nauki Kazahstana*], 2 (120), 38-48 [in Russian].